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Amino acid distribution of cereals in commerical mill products

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In Egypt, cereals play an important part in the diet, providing 70 % of the calories and 66.5 % of the protein intake (1). The degree and type of milling used in their preparations has an important effect upon the concentration of the nutrients available to the consumer.

For this reason it is important to know the distribution of proteins and amino acids of cereals in commercial mill products that serve as sources for human food and animal feeds.

Therefore the main object of the present work was to determine quantitatively the distribution of proteins and amino acids among and the products resulting from the commercial milling of wheat and rice.

Materials and methods

Materials

Samples of cleaned wheat and the products milled from it (flour, fine and coarse brans) were kindly supplied from Nasser Miller, Zagazig, Egypt. The tested samples of wheat are imported from Australia and used for the production of baker's flour. The extract rate was reported to be 82 %. Samples of brown rice and the products milled from it (germ, bran, and milled rice) were kindly supplied from "Sharkia Company for Rice Milling", Zagazig, Egypt. The Egyptian short grain rice varieties, Nahda and Giza 171, were used for the production of milled rice.

Methods

Amino acid composition in all the samples were determined by hydrolyzing with HCl (6 N) (2). The hydrolyzate was evaporated under vacuum till dryness, then dissolved in HCl (0.1 N containing 12.5 % sucrose) and analysed for amino acid composition with Technicon® amino acid analyzer (3). The technicon standard mixture of 2.25 µmole each of amino acids was used in calibrating the 75-cm and 0.62-cm diameter column. The average reproducibility of recovery obtained for the 17 amino acids was 100 ± 3 %. Results were expressed as g amino acid per 16 g N for the wheat components and per 16.8 g N for rice components (which amounts the same as expressing the data as percent of the protein content). The samples were analysed for Kjeldahl nitrogen (4). Crude protein was calculated from Kjeldahl nitrogen by multiplying by the factor 5.9 (5) for the rice components as recommended by Jones (6) before, and the factor 5.7 for the wheat components (7).

Results and discussion

Distribution of protein and amino acids of wheat in commercial mill products

As a percentage of dry weight, the protein content of wheat grain, fine and coarse brans was higher than that of flour (endosperm) (table 1). Stevens et al. (8) found that the protein content of wheat grain, germ, and bran was higher than that of flour. Jones (9) stated that, using 80 % extraction from wheat grain, the protein content of flour, fine feed, and bran were 12 %, 14.3 % and 12.4 %, respectively. Bran and fine wheat feed are used as constituents of "compound animal feeds". Consequently, the nutritional benefits of increasing the protein of the whole grain is not eliminated by milling. The decrease in protein of wheat grains during milling was 13.9 % at flour recovery of 86.1 %.

The mill products of wheat were subjected to acid hydrolysis and their amino acid composition is given in table 1. High contents of glutamic acid (probably in the intact protein as glutamine) and proline, whereas low contents of lysine, methionine, and histidine in grain and flour are notable. Less amounts of lysine, glycine, arginine, alanine, and aspartic acid are found in flour, whereas more amounts of these acids are found in grain. Conversely, higher values of proline, glutamic acid, and phenylalanine are found in flour than those in grain. The proportions of the other amino

Table 1. Amino acid distribution of wheat in commercial mill products and provisional FAO amino acid patterns (g/16 g N).

Amino acid	Whole grain	Flour 82% extraction	Fine bran	Course bran	FAO (1957) provisional pattern
Aspartic acid	4.93	3.68	8.16	8.04	–
Threonine (a)	2.93	2.40	3.36	3.55	3.02
Serine	4.26	4.32	4.94	4.86	–
Glutamic acid	29.76	32.60	20.16	20.48	–
Proline	9.76	10.88	5.76	5.82	–
Glycine	3.83	3.04	6.64	6.42	–
Alanine	4.26	2.72	5.23	5.55	–
Valine (a)	4.32	3.90	5.17	4.96	4.54
Cystine	3.04	2.29	2.56	2.72	–
Methionine (a)	1.50	1.28	1.76	1.60	2.42
Isoleucine (a)	3.20	3.47	2.62	3.20	4.54
Leucine (a)	6.69	6.40	7.46	6.56	5.15
Tyrosine	2.78	2.09	2.94	2.94	–
Phenylalanine (a)	4.48	4.64	4.26	4.16	3.02
Lysine (a)	2.78	1.81	3.69	3.84	4.54
Tryptophan (a)	b	b	b	b	1.51
Histidine	2.29	1.94	2.56	3.10	–
Arginine	4.61	3.09	6.93	7.36	–
Protein % (c)	10.57	9.1	12.53	12.16	–

a) Essential amino acid
b) No value available
c) Dry weight basis

acids are slightly affected by milling. These findings are in good agreement with those obtained with microbiological analysis of wheat grains and wheat flour as reported by Hepburn et al. (10), however, the protein contents were variable. Their data for grains are to some extent similar to those in table 1 with exception for alanine, cystine, and serine. High contents of glutamic acid and aspartic acid, low content of methionine for coarse and fine brans are notable. The data of Lyman et al. (11) obtained by microbiological analysis were similar to those in table 1 for coarse and fine brans except for their higher value for lysine. The data also indicated that lysine of the protein in coarse and fine brans is higher than that of the flour protein as it is twice in protein of these tissues compared with that in flour (endosperm). The results agreed with those of Stevens et al. (8) who found that the lysine content is 2–2.5 times in the proteins of these tissues compared with that in flour. It has been known since the classical work of Osborne and Mendel (12) that wheat protein is deficient in lysine. The work of Rose et al. (13) has established that the requirement of lysine is higher than for any of the other essential amino acids. Thus, the nutritive value of wheat protein is limited by its low lysine content. In general, the nutritional value of the protein of all mill products of wheat shows that they are deficient in threonine, methionine, isoleucine, and lysine compared with the provisional reference of amino acid pattern of the food and Agricultural Organization of the United Nations (14) (table 1). However, these are only tentative standards and a recent appraisal (15) suggested the need for possible changes.

Distribution of protein and amino acids of rice in commercial mill products

As a percentage of dry weight, the protein contents of brown rice, germ and bran were higher than that of milled rice (table 2). Consequently, the nutritional benefits of increasing the protein of brown rice is not eliminated by milling. The decrease of protein of brown rice during milling was 10.42 % of milled rice recovery of 89.58 %. These results agreed with those of Cagampang et al. (16) who found that the protein content of brown rice bran was higher than that of milled rice, and the decrease in protein of brown rice during milling ranged from 11 to 26 % at milled rice recovery of 86 to 90 %. The present data obtained for protein content of milled rice (6.19 %) is in the same order and magnitude as that reported for milled samples of the same varieties as stated by El-Saied (17).

The bran has a lower protein content than the germ, and this indicates that the outermost layer of the rice grain may not have the highest protein content. In fact, more refined milling of successive layers of brown rice by Primo et al. (18) and Hogan et al. (19) demonstrated that the fraction with the highest protein level was not the outermost 5 % fraction, but the second outermost 5 % fraction. The present data obtained for protein content of bran (11.83 %) is similar to that given by Lyman et al. (11) (12.54 %). The mill products of rice were subjected to acid hydrolysis, and their amino acid composition are given in table 2. The amino acid analysis of brown and milled rice shows that the predominant amino acids are glutamic acid and aspartic acid. The analyses obtained are much higher in glutamic acid and aspartic acid contents than those reported by Kik (20)

Table 2. Amino acid distribution of brown rice in commercial mill products and provisional FAO amino acid patterns (g/16.8 g N).

Amino acid	Brown rice	Milled rice	Germ	Bran	FAO (1957) provisional pattern
Aspartic acid	9.42	10.75	9.41	8.53	-
Threonine (a)	3.60	3.90	4.44	4.12	3.02
Serine	4.51	5.04	4.22	3.19	-
Glutamic acid	18.45	18.00	16.85	17.79	-
Proline	4.24	4.93	5.21	3.93	-
Glycine	5.04	5.54	6.05	3.46	-
Alanine	5.85	5.88	6.70	5.88	-
Valine (a)	5.20	5.84	4.87	5.71	4.54
Cystine	1.01	1.24	2.02	2.02	-
Methionine (a)	2.35	2.02	1.88	2.18	2.42
Isoleucine (a)	3.70	4.65	3.26	3.91	4.54
Leucine (a)	7.74	8.58	6.74	8.30	5.15
Tyrosine	2.91	3.43	3.09	3.26	-
Phenylalanine (a)	4.21	4.94	3.91	4.84	3.02
Lysine (a)	3.43	3.58	6.05	3.53	4.54
Tryptophan (a)	b	b	b	b	1.51
Histidine	2.05	2.42	2.59	2.18	-
Arginine	7.57	8.57	8.45	6.70	-
Protein % (c)	6.91	6.19	12.56	11.83	-

a) Essential amino acid
b) No value available
c) Dry weight basis

with microbiological assays and by Adda (21) with paper chromatographic analysis. The data of Juliano et al. (3), which were obtained by amino acid analyzer, are in good agreement with those in table 2 for brown and milled rice. Less amounts of aspartic acid, glutamic acid, serine, and proline are found in bran and germ, whereas more amounts of these acids are found in brown and milled rice. Conversely, higher values of threonine and cystine are found in bran and germ than those in brown and milled rice. Cagampang et al. (16) reported a similar observation for milled rice. The data of Chaven and Duggal (22), which were obtained for lysine and methionine in brown rice, are in good agreement to those in table 2. Moreover, the results of rice bran reported by Lyman et al. (11) with the microbiological assay agreed with those in table 2, except their higher values for leucine, however, the protein contents are nearly the same. The proportions of the other amino acids are slightly affected by milling, however, high content of lysine and glycine in germ is notable. Hepburn et al. (10) stated a similar observation regarding these two acids in wheat germ. In general, high levels of glutamic acid (probably in the intact protein as glutamine), aspartic acid, leucine and arginine, whereas low levels of methionine, cystine, and histidine in all the mill products of rice are notable. The nutritional value of the proteins of these products shows that they are deficient in isoleucine and lysine as judged by the provisional reference of amino acid pattern of the Food and Agricultural Organization of the United Nations (14) (table 2). However, milled rice contains suitable amounts of isoleucine, and germ contains suitable amount of lysine.

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Summary

The amino acid contents of wheat and rice as well as their final products produced by commercial milling were determined quantitatively by the amino acid analyzer. Less quantities of lysine, glycine, arginine, alanine, and aspartic acid were found in the flour, whereas more levels of these amino acids were found in the wheat grain. Conversely, more proline, phenylalanine and glutamic acid were found in the flour, and less amounts of these amino acids were found in the wheat grain. The proportion of the other amino acids were slightly affected by milling. On the other hand, less amounts of aspartic acid, serine, glutamic acid, and proline were found in rice bran and germ, whereas more levels of these amino acids were found in brown and milled rice. Conversely, rice bran and germ contained more threonine and cystine than brown and milled rice. The proportions of the other amino acids were slightly affected by milling, however, high content of lysine in germ was notable.

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